

IN THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the Application:

LISTING OF CLAIMS:

1. (Currently amended) A measurement apparatus for determining the angular position of a first member with respect to an elongated second member about a rotation axis extending in the direction of elongation of the second member, comprising:

an optical sensor head on the first member, the sensor head comprising a source of a light beam and a plurality of light detecting elements;

an offset beam generation element on the second member, the offset beam generation element being operative to receive the light beam from the source and to return an offset light beam to the sensor head, the offset light beam propagating at a predetermined non-zero offset angle with respect to the rotation axis between the first and second members to ~~providing~~ provide a light spot that travels in a generally elliptical path over the light detecting elements as relative rotation about the rotation axis occurs between the first and second members; and

a signal processor operative to process electrical signals produced by the detecting elements to determine the position of the offset beam of light along the elliptical path.

2. (Original) A measurement apparatus according to claim 1, wherein the light source comprises a solid state source.

3. (Original) A measurement apparatus according to claim 2, wherein the solid state source comprises a vertical cavity surface emitting laser.

4. (Original) A measurement apparatus according to claim 2, wherein the solid state source comprises a light emitting diode (LED).

5. (Original) A measurement apparatus according to claim 1, wherein the light detecting elements are disposed to form one or more annuli surrounding the light source.

6. (Original) A measurement apparatus according to claim 1, wherein the light detecting elements are arranged in a two dimensional array.

7. (Cancelled)

8. (Currently amended) ~~A measurement apparatus according to claim 1, A~~
measurement apparatus for determining the angular position of a first member
with respect to a second member about a rotation axis, comprising:
an optical sensor head on the first member, the sensor head comprising a
source of a light beam and a plurality of light detecting elements;
an offset beam generation element on the second member, the offset
beam generation element being operative to receive the light beam from the
source and to return an offset light beam to the sensor head, the offset light
beam providing a light spot that travels in a generally elliptical path over the light
detecting elements as relative rotation occurs between the first and second
members; and
a signal processor operative to process electrical signals produced by the
detecting elements to determine the position of the offset beam of light along the
elliptical path,
wherein the beam generation element produces at least a first beam of
light and a second beam of light, the first and second beams propagating
towards the light detecting elements, the direction of propagation of the first
beam being at a predetermined angle with respect to the rotation axis and the

direction of propagation of the second beam being substantially along the rotation axis.

9. (Original) A measurement apparatus according to claim 1, wherein the beam generation element is reflective.

10. (Original) A measurement apparatus according to claim 9, wherein the beam generation element comprises a planar reflective surface mounted at a predetermined angle with respect to the rotation axis.

11. (Currently amended) ~~A measurement apparatus according to claim 9, A~~
measurement apparatus for determining the angular position of a first member
with respect to a second member about a rotation axis, comprising:
an optical sensor head on the first member, the sensor head comprising a
source of a light beam and a plurality of light detecting elements;
an offset beam generation element on the second member, the offset
beam generation element being operative to receive the light beam from the
source and to return an offset light beam to the sensor head, the offset light
beam providing a light spot that travels in a generally elliptical path over the light
detecting elements as relative rotation occurs between the first and second
members; and
a signal processor operative to process electrical signals produced by the
detecting elements to determine the position of the offset beam of light along the
elliptical path,
_____ wherein the beam generation element comprises a reflective diffractive
optical element (DOE), the DOE diffractively producing at least one beam of light
propagating towards the light detecting elements, the direction of the propagation
being at a predetermined angle with respect to the rotation axis between the first
member and the second member.

12. (Original) A measurement apparatus according to claim 11, wherein the DOE comprises a linear diffraction grating.

13. (Original) A measurement apparatus according to claim 11, wherein the DOE is a binary diffuser.

14. (Currently amended) ~~A measurement apparatus according to claim 1,~~ A measurement apparatus for determining the angular position of a first member with respect to a second member about a rotation axis, comprising:
_____ an optical sensor head on the first member, the sensor head comprising a source of a light beam and a plurality of light detecting elements;
_____ an offset beam generation element on the second member, the offset beam generation element being operative to receive the light beam from the source and to return an offset light beam to the sensor head, the offset light beam providing a light spot that travels in a generally elliptical path over the light detecting elements as relative rotation occurs between the first and second members; and
_____ a signal processor operative to process electrical signals produced by the detecting elements to determine the position of the offset beam of light along the elliptical path,
_____ wherein the beam generation element is transmissive.

15. (Original) A measurement apparatus according to claim 14, wherein the beam generation element comprises a prismatic element operative to impart an angular shift to the beam from the source.

16. (Original) A measurement apparatus according to claim 14, wherein the beam generation element comprises a transmissive diffractive optical element (DOE), the DOE diffractively producing at least one beam of light propagating towards the light detecting elements, the direction of the propagation being at a

predetermined angle with respect to the rotation axis between the first member and the second member.

17. (Currently amended) ~~A measurement apparatus according to claim 1, A~~
measurement apparatus for determining the angular position of a first member
with respect to a second member about a rotation axis, comprising:
an optical sensor head on the first member, the sensor head comprising a
source of a light beam and a plurality of light detecting elements;
an offset beam generation element on the second member, the offset
beam generation element being operative to receive the light beam from the
source and to return an offset light beam to the sensor head, the offset light
beam providing a light spot that travels in a generally elliptical path over the light
detecting elements as relative rotation occurs between the first and second
members; and
a signal processor operative to process electrical signals produced by the
detecting elements to determine the position of the offset beam of light along the
elliptical path,
wherein the beam generation element produces at least a first beam of
light and a second beam of light, the beams propagating towards the light
detecting elements, wherein the first beam of light is adapted to have a
predetermined unique characteristic.

18. (Original) A measurement apparatus according to claim 17, wherein the signal processor of the apparatus is adapted to identify the first beam of light based on the predetermined unique characteristic.

19. (Original) A measurement apparatus according to claim 17, wherein the predetermined unique characteristic is the polar angular location of the spot generated by the first beam of light.

20. (Original) A measurement apparatus according to claim 17, wherein the predetermined unique characteristic is the optical intensity of the first beam of light.

21. (Original) A measurement apparatus according to claim 1, further comprising an aperture disposed between the sensor head and the offset beam generation element, the aperture being operative to reduce the size of the light spot on the light detecting elements from the offset light beam.

22. (Original) A measurement apparatus according to claim 1, further comprising a lens disposed between the sensor head and the offset beam generation element, the lens being operative to reduce the size of the light spot on the light detecting elements from the offset light beam.

23. (Currently amended) A measurement apparatus according to claim 1, A measurement apparatus for determining the angular position of a first member with respect to a second member about a rotation axis, comprising:
an optical sensor head on the first member, the sensor head comprising a source of a light beam and a plurality of light detecting elements;
an offset beam generation element on the second member, the offset beam generation element being operative to receive the light beam from the source and to return an offset light beam to the sensor head, the offset light beam providing a light spot that travels in a generally elliptical path over the light detecting elements as relative rotation occurs between the first and second members; and
a signal processor operative to process electrical signals produced by the detecting elements to determine the position of the offset beam of light along the elliptical path,
wherein the beam generation element produces at least three beams of light propagating towards the light detecting elements, the direction of

propagation of each beam being at a respective predetermined angle with respect to the rotation axis.